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TESTS OF DDT AGAINST GRASSHOPPERS IN 1944

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Dusts

A preliminary test of 25 percent of DDT in pyrophyllite was conducted in Arizona in May. Nearly mature alfalfa, Johnson grass, Bermuda grass, and weeds growing on ditchbanks at the margin of an alfalfa field were dusted until the vegetation was white (approximately 30 pounds of the dust mixture per acre). Adults and late instars of the grasshopper Melanoplus mexicanus (Sauss.) had gathered in large numbers, 50 to 75 per square yard, and were roosting on the upper parts of the vegetation. The dust was applied in the early morning at a temperature of 74° F. and while the vegetation was covered with a heavy dew. Within 15 minutes many of the grasshoppers showed distress and were descending to the ground; in 2 hours they were all down. None were dead in 3 hours, but the majority could move only slightly when disturbed. Approximately 150 grasshoppers in a screen cage, which were dusted immediately after dust was applied to grasshoppers in the open, were all dead in 1 hour. When the ditchbanks that had been dusted were visited the following morning, all the grasshoppers were either dead or unable to hop. The vegetation was still white with dust and, since the location was one where grasshoppers sought shade in the hotter parts of the day and shelter at night, a decision was made to determine the effect of the dusted vegetation upon undusted grasshoppers that moved into it. Two plots 6 feet long by 3 feet wide were marked off and all dead and dying grasshoppers removed. The daily counts of dead grasshoppers removed from the plots for 8 consecutive days are shown in table 1.

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Table 1.--Daily counts of dead grasshoppers removed from plots in vegetation previously dusted with 25 percent of DDT in pyrophyllite, near Tempe, Ariz., 1944

Date	Plot 1	Plot 2	Date	Plot 1	Plot 2
May 15	35	41	May 19	11	20
16	45	25	20	8	10
17	13	16	21	6	8
18	9	20	22	<u>1</u>	<u>2</u>
		Total .....		128	142

Large numbers of other insects, sowbugs, and spiders were also killed. Although the foliage was dusted heavily while wet with dew, no injury could be detected within 8 days.

During July, in a test made at Sheridan, Wyo., considerable quantities of a factory-mixed dust containing 10 percent of DDT in pyrophyllite were applied with both hand and power dusters to heavy infestations of grasshoppers in various types of vegetation. In no instance was satisfactory control obtained. Attempts were then made to increase the strength of the dust to 15 and 20 percent of DDT by adding the necessary quantities of technical DDT. Considerable difficulty was experienced in trying to mix evenly the technical DDT with the 10 percent dust, and the results of the tests were so erratic that no conclusions could be drawn as to the comparative effectiveness of the different dusts. Excellent kills were sometimes obtained by drift dusting with both 15 and 20 percent DDT dusts, but in other instances the results were unsatisfactory. In some tests the 20 percent strength gave better results than the 15 percent, whereas in others the results were reversed. The dusts were applied with a power duster equipped with a single outlet. A great deal of difficulty was encountered in applying definite quantities of dust per acre with this machine, which may have contributed to the variable results.

During late August and early September, factory-mixed dusts containing 10, 15, 20, and 25 percent of DDT in pyrophyllite were applied to heavy stands of tall alfalfa with a multiple-outlet power duster. With this machine there was little drift and the quantity applied per acre could be accurately gaged, although distribution within the swath was unsatisfactory. The outlets at each end of the boom discharged greater volumes of dust than those next to them, and considerably greater volumes than the two center outlets. Had the discharge from all outlets been uniform, equally good results could undoubtedly have been obtained with smaller quantities of dust per acre. All dusting

was done in either the early morning or late evening because there was less wind at such times. Temperatures were between 60° and 70° F. No comparison was made of the effects of similar dust mixtures applied at higher temperatures. Three tests are summarized in table 2. The percent killed is based on the numbers of grasshoppers found dead on the plots 2 days after dusting as compared with the number alive before dusting. This is not exact because some dusted grasshoppers may have left the plots to die or to recover elsewhere. There is also considerable error in estimating numbers of live grasshoppers, particularly when they exceed 15 per square yard. The numbers dead per square yard were obtained by actual counts on not less than 10, and generally 20, well-distributed square-yard quadrats on each plot. Estimates of live grasshoppers are visual counts made by walking through the plots before and after dusting.

Table 2.—Effectiveness against grasshoppers of various DDT-pyrophyllite mixtures applied as dusts on heavy stands of alfalfa, Sheridan, Wyo., 1944

Test	Concen- tration of DDT	Dosage of—		Area dusted	Grasshoppers per square yard			Percent killed
		Mixed dust	DDT		Before dusting	2 days after dusting	Alive	
	Percent	Pounds per Acre	Acres	Number	Number	Number		
1	25	10	2.5	2.0	8	1	5.2	65.0
	20	10	2.0	2.0	8	2	2.9	36.2
	15	10	1.5	2.0	8	3	1.7	21.2
	10	10	1.0	2.0	8	4	.7	8.7
2	25	20	5.0	1.0	30	2	27.0	90.0
	20	20	4.0	1.0	20	3	18.0	90.0
	15	20	3.0	1.0	25	2	20.0	80.0
	10	20	2.0	1.0	25	10	12.0	48.0
3	25	17	4.25	.6	10	2	9.0	90.0
	20	20	4.0	1.0	15	2	16.0	100.0
	15	14	2.2	1.5	12	3	10.0	83.3
	10	14	1.4	1.5	12	10	3.0	25.0

The tests indicate that 20 pounds per acre of 20 or 25 percent DDT dust will practically eliminate grasshoppers from heavy stands of tall alfalfa. Both 14 and 20 pounds of 15 percent DDT dust also reduced populations to noneconomic numbers. It seems probable that 15 pounds per acre of the 15-percent dust applied with a more efficient multiple-outlet power duster would consistently give satisfactory control.

The dominant species of grasshoppers present in the dusted plots were Melanoplus mexicanus (Sauss.), M. bivittatus (Say), and M. femur-rubrum (Deg.). No differences could be detected in their reaction to DDT dusts. The effects of DDT were apparent within half an hour after dusting. The grasshoppers became excited, descended from vegetation, and wandered aimlessly about manifesting distress. Many were down on their sides within 3 or 4 hours, but few were found dead the first day. In 48 hours the great majority were either dead or moved only feebly when disturbed. If the dust was not washed off by rains or blown away by heavy winds, it continued to kill for approximately a week. Grasshoppers that were not killed showed a tendency to leave the dusted plots, and unless the infestation on adjacent vegetation was extremely heavy few of these insects invaded foliage well covered with DDT dust.

In making counts of dead grasshoppers on dusted plots, careful watch was kept for dead or sick bees, but in several hundred square yards examined none were found. Dusts were always applied in the early morning or late evening while bees were absent, but numerous bumblebees and honeybees were seen visiting blooms on dusted plots within 24 hours after treatment. Carabid beetles were particularly sensitive to DDT dust, and frequently were on their backs a few minutes after the dusting. The common field cricket (Gryllus assimilis (F.)) was very abundant on many of the plots and was more susceptible to DDT than grasshoppers. In one instance, where there was a light drift of dust from a treated plot to an adjoining field, dead crickets were found 150 feet beyond the plot.

No trace of foliage injury from DDT was noted at any of the dosages used.

#### Sprays

Dust mixtures of DDT in pyrophyllite, suspended in water containing 1 ounce of Areskap (sodium monosulfonate of butylphenylphenol) to 100 gallons of water, made a spray material which spread evenly, adhered well to alfalfa foliage, and did not clog the nozzles or settle rapidly in the spray tank while the agitator was in operation. This mixture was applied with a 100-gallon power sprayer, which was equipped with two hose lines and two spray guns and was capable of maintaining a pressure of 300 pounds per square inch. Difficulty was experienced in obtaining equal delivery from the spray guns and the spray was too coarse. It seems certain that a more uniform coverage could have been obtained with less material per acre, if a power field sprayer equipped with a boom and multiple nozzles set to provide a foglike spray had been available. Summaries of two tests conducted in heavy stands of tall alfalfa are shown in table 3.

Table 3.—Effectiveness against grasshoppers of 20 percent and 15 percent DDT-pyrophyllite mixtures when applied as sprays on heavy stands of alfalfa (20 pounds of the mixture per 100 gallons), Sheridan, Wyo., 1944

Test	Concen- tration of DDT	Dosage per acre		Area sprayed	Grasshoppers per square yard			Percent killed
		Mixed spray	DDT		Before spraying	3 days after spraying		
		Percent	Gallons	Pounds	Alive	Dead		
1	20	200	8.0	0.5	28	1	26	92.8
	15	150	4.5	.75	15	4	12	80.0
2	20	100	4.0	1	25	3	23	92.0
	15	100	3.0	1	20	3	17	85.0

The tests indicate that both 15 and 20 percent of DDT applied in spray form at the rate of 20 pounds of the dust mixture in 100 gallons of water per acre will reduce heavy concentrations of grasshoppers to non-economic numbers. The killing action of DDT was slower in the sprays than in the dusts, but it continued for a longer period. Grasshoppers on sprayed plots 3 days after treatment were in about the same condition as grasshoppers on dusted plots after 2 days. Newly dead and sick grasshoppers were found on sprayed plots 10 days after treatment. No dead bees were found on sprayed plots, but dead carabids and field crickets were found in about the same numbers as on dusted plots. No injury to foliage was noted even when plants remained heavily coated with spray material for several weeks.

#### Aerosols

One indoor and one outdoor test was conducted to determine the effect upon grasshoppers of DDT dispersed as an aerosol. An aerosol bomb containing pyrethrum extract (20 percent pyrethrins) 1.5 percent, DDT 3 percent, lubricating oil 5 percent, methylene chloride 30 percent, and Freon-12 (dichlorodifluoromethane) 60.5 percent was supplied by the Division of Insecticide Investigations. In the indoor test grasshoppers in screen cages were placed in a closed room containing 1,800 cubic feet. An electric fan was used to circulate air through the cages. The room temperature was 86° F. The bomb was opened for 10 seconds. Within 2 minutes the grasshoppers started to jump frantically; in 3 minutes all were salivating copiously; in 5 minutes some were down on their sides on the bottom of the cages; in 13 minutes approximately 50 percent were down; in 30 minutes 95 percent were down and the room was then opened. In order to test the effect of varying lengths of exposure, some of the cages were removed from the room 2, 5, 10, 15, 20, 25, and 30 minutes after the aerosol was released. The mortality in the various cages at the end of 3 days is shown in table 4.

Table 4.--Mortality of grasshoppers in 3 days after exposure for various lengths of time to DDT-pyrethrum aerosol dispersed in a closed room, Sheridan, Wyo., 1944

Exposure	Grasshoppers in cage	Insects alive after 3 days	Percent killed
<u>Minutes</u>	<u>Number</u>	<u>Number</u>	
2	103	98	4.9
5	278	171	38.5
10	130	99	23.8
15	172	116	32.6
20	147	128	12.9
25	110	75	31.8
30	88	50	44.4

The grasshoppers alive 3 days after exposure were all active and showed none of the earlier effects of the DDT.

The outdoor test of the DDT aerosol bomb was conducted in tall vegetation growing along a sheltered ditchbank. The test was conducted in the late evening while large numbers of grasshoppers were roosting 6 to 8 feet above the ground. The temperature was 62° F. and there was no perceptible air movement. The DDT bomb was opened for 1 minute, rotated slowly through a half circle from a point at the edge of the weeds, and directed into the space below the roosting grasshoppers. In 3 minutes many grasshoppers were dropping to the ground; in 5 minutes all that could be seen were salivating freely and many were on their sides; in 10 minutes all grasshoppers within 15 feet from the point of discharge were down from the weeds and large numbers were unable to jump when touched; in 30 minutes grasshoppers were found affected 25 feet away from the point of discharge, and through a radius of 10 feet most of the numerous grasshoppers on the ground were on their sides and moved only when picked up. The following morning the grasshoppers were in about the same condition. Only a few were dead, but large numbers were on their sides unable to move. Many carabid beetles were dead, and a solitary Mormon cricket could barely get to its feet. When a final check was made 2 days later a flock of blackbirds was searching the weeds for grasshoppers. Pieces of grasshopper wings and legs indicated that many grasshoppers had been eaten. Scattered dead ones were found 15 feet from the point of discharge, but they composed only a small percentage of the number sick 2 days previously. Whether the sick grasshoppers recovered and moved away or were eaten by blackbirds before or after they died could not be determined. Judging from the results of the indoor tests, it seems probable that many of them recovered.

Termination of field operations shortly after the aerosol bomb was received prevented further experimentation.

### Discussion of Results

Grasshoppers were highly susceptible to DDT in dusts, sprays, and aerosols. Twenty pounds per acre of 15 percent of DDT in pyrophyllite applied either as a dust or spray reduced heavy infestations of grasshoppers to noneconomic numbers without injury to foliage. With more efficient dusting and spraying equipment, it seems likely that control can be secured with smaller quantities per acre.

Unless washed off by heavy rains, DDT applied as a spray continued to kill over a period of several weeks, and in this respect was more effective than dust, which was removed by either wind or rain. Both sprays and dusts exhibited marked repellent effect. Sprayed or dusted plots of one-half acre or more, on which grasshoppers had been reduced to several per square yard, remained very lightly infested for several weeks although surrounded by infestations of 10 to 25 per square yard.

At the present time the use of DDT in some form seems to offer the most promise of controlling grasshoppers in seed alfalfa and other tall, dense vegetation. It is the only material tested thus far which has killed high percentages of grasshoppers without injuring the vegetation, but the persistence of residues on the plants and the livestock-poisoning hazard involved remain to be determined. The fact that no dead bees were found in the treated plots does not necessarily mean, of course, that the DDT did not cause any mortality of these or other insects which pollinate alfalfa. This subject needs further investigation. It seems possible, however, that control of grasshoppers could be secured by applying DDT before the blooming period while pollinating insects are absent from the treated fields.

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